Energy Consumption and Greenhouse Gas Emission Evaluation Scenarios of Mea Fah Luang University

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Abstract. In Thailand, quantity of the educational institutes building shared one fourth of commercial building. Among the energy consumption and conservation in the building in Thailand are mostly study in typical office and resident building. Mea Fah Luang University (MFU) was selected to represent the educational institutes building where located in the northern part of Thailand. The average temperature in the northern is lower than other parts of Thailand. This study was firstly collected the data about quantity and behaviour of energy consumption in MFU based on the energy audit handbook. Although MFU is located in the northern of Thailand. The highest energy consumption is in the part of air condition. When the energy efficiency appliances and energy conservation building are implemented, the cost of energy will be saved around 15,867,960 Baht. Furthermore, the greenhouse gas emission is also reduced about 72.01 kg CO_2, equivalent/m^2/year.

1 Introduction

As the final energy consumption static in Thailand, the first two energy consumption sectors are industrial and commercial sectors, respectively. The electricity is consumed in commercial sector around 48,927.8 GWh/year during (2005-2012). This results in 29,638.8 Mton CO2 emission/year. [1]. Most of electricity is spent to operate the building in this sector. [2]. Noted that official buildings presented the highest energy consumption by surface [3]. The pervious works recommended that more than 70% of energy consumption in the building is used for air condition and lighting system. [2]-[5]. These could be said that energy conservation in the building is one of significant method for reduce greenhouse gas emission. However, the climate and the season should be investigated during developed the convection campaign [6], [7]. The temperature play the major affected to energy loading of air condition/heating system. Moreover, daytime in each season is also influence to the energy consumption in lighting system.

Universities are one of interested section that can reduce energy consumption and mitigate GHG emission [8]-[10]. Saidur [5] collected the data of the building age, operating hour and quantity of electric equipment in the office building. Then these data was used to calculate evaluate the energy saving cost and greenhouse gas mitigation under different energy saving measures. It was found that housekeeping, increasing of thermostat setpoint temperatures and setting standby mode are none investment cost for energy conservation. Replacement of

incandescent with compact fluorescent and the use of insulation are the saving method with very short payback compared to lifespan. Escobedo, Briceño [11] evaluated quantity of energy consumption and greenhouse gas emission in each build of the National Autonomous University of Mexico. Then, investment cost for energy conservation was calculated to compare with energy saving bill. Finally, they suggested that replacement of incandescent with compact fluorescent T12 and T8 lamp, changing magnetic ballast to electronic ballast, installation of hybrid energy system are worth for investment. Moreover the university should support the energy saving campaign among student and occupants. Azar and Menassa [12] study the possibility of energy saving by increasing the efficiency of the commercial building operation. Then they developed the mathematical model to forecast the energy consumption in different building scale. Moreover, the human behavior if each build was also studied. They conclude that reinforce the role of human actions in energy conservation, and support efforts to integrate operation-focused solutions in energy conservation policy framework influence to reduce energy consumption around 21%.

In Thailand, quantity of the educational institutes building shared one fourth of commercial building [13]. The Green University policy is also implemented. During 2011-2015, number of Thailand's Green University, which is ranked by UI GreenMetric World University Ranking, is increased continuously [14]. Among the energy consumption and conservation in the building in Thailand are mostly study in typical office and resident

building. [13] This study was developed to provide alternative solution for institute in Northern Thailand where the winter period is longer than other regions.

2 Methodology

This study was firstly survey the general information of energy consumption in Mea Fah Luang University. Then, a representative sample of buildings are selected in order to estimate energy consumption by end use. The representative of the sample was selected based on the difference building age. It should to note that MFU kicked off the Green University project in 2012. After that, the buildings were designed under the criteria and standards for energy conservation according to the National Energy Conservation Promotion Act. The energy of the selected building were audited follow the guideline of energy audits handbook [15]. Based on data collected from energy audits, an indicator of energy use by end use per occupant was estimated. Since this study was developed in 2014, the information of energy consumption is also used as base year for comparison with alternative scenarios. As mention above, the building which established before 2012 was not fully relied on energy conservation criteria. Thus, E1 building was chose as representative. On the other hand, the E3A building was also selected to represent the building that design under energy conservation criteria. All electric appliances are high energy efficiency which are labeled No.5.

2.1 CO₂ emission calculation

The emission is calculated by using the IPCC's guideline [16], Eq.1. Meanwhile the emission faction is based on the national information [17]. It should to note that the electricity that supply to MFU is generated from coal.

$$CO_2eq\ Emission = Energy\ consumption(watt)\ x\ EF \quad (1)$$

where CO_2, eq is CO_2 equivalent

$$EF\ is\ émission\ factor\left(\frac{CO_2eq}{watt}\right)$$

2.2 Energy cost saving cost calculation

To calculate the energy cost saving in the build, the following approaches as proposed by Staniaszek and Lees [18] will be used: Firstly, electric machines were categories into 4 main groups consisting (i) Electrical Lighting (ii) Air condition (iii) Office Appliances and (iv) Other Electrical Appliances. After that, unit of each electrical appliance was calculated by following formula, Eq. 2.

$$Electricity\ Unit\left(\frac{kWh}{day}\right) = \frac{No.power\ supplies\ x\ P\ x\ t}{1000} \quad (2)$$

where No. power supplies is number of power supplies
    P is power (watt)
    t is time (hour)

Then we find annual unit (kWh) by multiply with 22 days per months for electrical appliances that were not used on weekend and 30 days per months for electrical appliances were used on weekend. Furthermore, we can calculate the annual cost of electrical used by multiplying the annual unite (kWh) by the electricity rates. So, annual energy cost saving of each group of appliances was determined by Eq. 3.

$$Anu.en.saving = Anu.en\ B1 - Anu.\ en\ B2 \quad (3)$$

where Anu.en. is annual energy cost (Baht).
    B is building
The future value of annual costs saving are estimated by using Eq.4-5.

$$Forcasted\ anu.en = anu.en\ saving \times fut.val\ factor \quad (4)$$

$$fut.val.factor = (1 + i)^n \quad (5)$$

where i = discount rate and n = number of periods

In addition, we conducted the future value cumulative or total cost saving of each group of appliances by sum the future value of annual costs saving on period of appliances useful life. Finally, we will get the efficiency of electrical appliances which were implemented at the selected building in term of energy costs saving.

3 Results and discussion

3.1 The university characteristics

Mea Fah Luang University is located in mountainous area. The infrastructures in the university are official buildings, dormitories, sport complex, laboratories, and facilities, etc. The academic year is divided into 2 semesters. The 1st semester is during June-September. The 2nd semester is during November-February. According to the temperature distribution in Northern of Thailand during 1999-2004 is presented in Fig. 1. The average temperature of the first and the second semester are 28.54 °C and 23.64 °C, respectively. This correspond to amount of energy consumption though the year, Fig. 2. It could be seen that energy consumption in the 1st semester is higher than the 2nd semester. However, the annual energy consumption is different since the increasing of building area and number of staffs and students. However, the energy intensity during 2011-2014 is deceased since the energy conservation policy of MFU. This also results in lower carbon emission from energy consumption as shown in Table 1.

Table 1. Energy consumption and GHG emission in MFU during 2011-2014

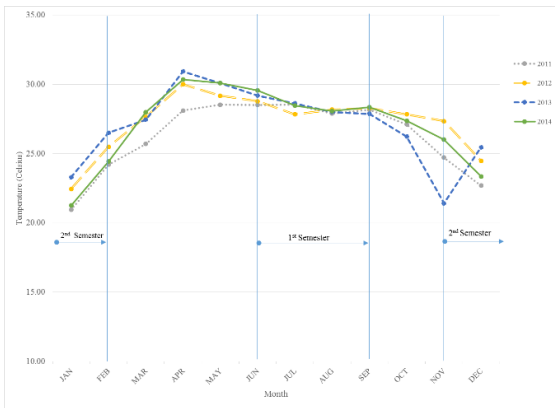| Year	Energy consumption (kWh/person)	GHG emission (TonCO₂eq/person)
2011	1181.94	0.72
2012	1136.20	0.69
2013	802.12	0.49
2014	857.63	0.52

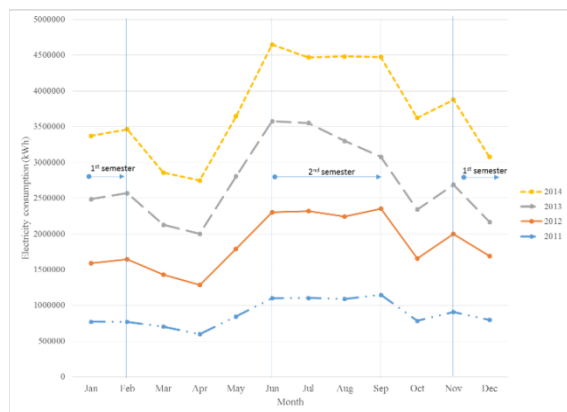**Figure 1.** Mean temperature in Northern of Thailand during 2009-2014.

Figure 2. Energy consumption in Mea Fah Luang University during 2009-2014.

3.2 Energy consumption behavior

One parameter that affects to quantity of energy consumption is energy consumption behavior of occupants. Thus, the behavior was randomly survey in six buildings difference age. As seen in Fig. 3, the air condition is the largest energy consumption. This might be the effect of the climate as mention above. Moreover, the officers did not play attention to switch off/unplug the electric appliances even though there are not used.

3.3 Energy saving potential

3.3.1 Base case

The study was developed in 2014 where the total of energy consumption is 12,036,777.82 kWh. Total Floor area is 327,264.18 m^2. So the energy consumption per area is 36.78 kWh/m^2. The CO_2 emission is 22.4 $kgCO_2$, eq/m^2.

3.3.2 Alternative scenario

Firstly, quality of energy consumption in E3A Building and E1 Building was identified. Then, the annual costs saving when compared between E3A building and E1 building was calculated as four catalogs. The annual costs saving and the future value of annual costs saving on period of appliances useful life of electrical lighting, air

condition, office appliances and other electrical appliances are presented in Table 2-5, respectively. Finally, we will get the efficiency of electrical appliances which were implemented at E3A Building and E1 Building in term of energy costs saving.
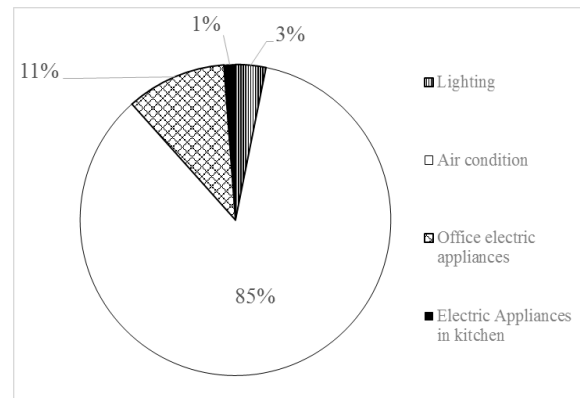

Figure 3. Energy consumption ratio of Mea Fah Luang University during academic year 2014

Table 2. Energy cost saving for electrical lighting

Periods (n)	Annual Costs saving (x10^3Baht)	Future Value Factor, 10% Interest Rate	Future Value of Annual Cost Saving (x10^3Baht)	Future Value Cumulative Costs Saving (x10^3Baht)
0	148.68	1.00	148.68	148.68
1		1.21	179.90	328.59
2		1.22	181.54	510.13
3		1.33	197.90	708.02
4		1.46	217.67	925.69
5		1.61	239.53	**1,165.,22**

The electrical lighting saving cost, Table 2, for this activity calculated on the basis of annual costs using in 2014. Lighting bulb was estimated to have a useful life of 7 years. In this study, the discount rate of 10 percent was used to find the future value of annual cost saving. The annual costs saving of electrical lighting compare between E3A Building E1 and Building in 2015 was 148,681 Baht. Therefore, at the completely useful life of lighting bulb, the cumulative costs saving will be equal to 1,428,680 Bath.

In the case of air condition, it was estimated 10 years useful life and 10 percent discount rate, total cumulative costs saving of air condition. As seen in Table 3, the annual cost saving in 2014 was 766,142 which is the highest energy cost saving among 4 groups of electrical appliances. The table 4 illustrates office appliances which consist of printers, fax machines, computers and photocopy machines. The annual cost saving was 439,691 Baht, at the estimating of a useful life of office appliances were 5 years with 10 percent discount rate, the cumulative costs saving accounting for 2,737,522 Baht

The other electrical appliances, Table 5, including electric kettles, microwaves, and refrigerators. The annual cost saving was -96,769 Baht, at the estimating of a useful life of other electric appliances were 5 years with 10 percent discount rate, the cumulative costs saving accounting for -602,489 Baht. It is indicated that E1

Building has more efficiency energy saving than E3A on group of other electrical appliances.

Finally, it was found that the highest energy cost saving at the end of useful life of electric appliances was air condition (12,304,247 Baht), office appliances (2,737,522 Baht) electrical lighting (1,428,680 Baht) and other electrical appliances (-602,489 Baht) respectively. The total energy cost saving when comparing between E3A and E1 was equaled to 15,867,960 Baht.

In the part of greenhouse gas emission, replacement of high energy efficiency are influenced in GHG reduction around 72.01 kg CO_2,eq./m^2/year.

Table 3. Energy cost saving for air condition

Periods (n)	Annual Costs saving ($\times 10^3$Baht)	Future Value Factor, 10% Interest Rate	Future Value of Annual Cost Saving ($\times 10^3$Baht)	Future Value Cumulative Costs Saving ($\times 10^3$Baht)
0	766.14	1.00	766.14	766.14
1		1.21	927.03	1,693.17
2		1.22	935.46	2,628.63
3		1.33	1,019.74	3,648.37
4		1.46	1,121.63	4,770.00
5		1.61	1,234.26	6,004.26
6		1.77	1,357.60	7,361.86
7		1.95	1,493.21	8,855.07
8		2.14	1,642.61	10,497.68
9		2.36	1,806.56	**12,304,25**

Table 4. Energy cost saving for office appliances

Periods (n)	Annual Costs saving (Baht)	Future Value Factor, 10% Interest Rate	Future Value of Annual Cost Saving ($\times 10^3$Baht)	Future Value Cumulative Costs Saving ($\times 10^3$Baht)
0	439.69	1.00	439.69	439.69
1		1.21	532.03	971.72
2		1.22	536.86	1,508.58
3		1.33	585.23	2,093.81
4		1.46	643.71	**2,737.52**

Table 5. Energy cost saving for other electrical appliances

Periods (n)	Annual Costs saving (Baht)	Future Value Factor $(1+i)^n$, 10% Interest Rate	Future Value of Annual Cost Saving (Baht)	Future Value Cumulative Costs Saving(Baht)
0	-96.77	1.00	-96.77	-96.77
1		1.21	-117.09	-213.86
2		1.22	-118.16	-332.02
3		1.33	-128.80	-460.82
4		1.46	-141.67	**-602.49**

4 Conclusion

The quantity and behavior of energy consumption in MFU were collected based on the energy audit handbook. The energy consumption during 1st and 2nd semesters is higher than summer periods. Although MFU is located in the northern of Thailand where the average temperature is lower than other parts of Thailand. The highest energy consumption is in the air condition sector. When the energy efficiency appliances and energy conservation building are implement, the cost of energy will be saved around 15,867,960 Baht. Furthermore, the GHG emission is also reduced about 72.01 kg CO_2,eq/m^2/year. This is also benifited for university in Northen of Thailand. The energy conservation of the air conditons is also important though the temperature distribtion in the Northen is lower than 31 ^{o}C.

Acknowledgements

References

1. DEDE, *Thailand Energy Statistics 2012*, D.o.A.E.D.a. Efficiency, Editor, **72**, (2012).

2. N.Yamtraipat, et al., Energy Policy, **34**(7), 5 (2006).
3. B. Limmeechokchai and P. Chaosuangaroen, Thammasat Int. J. Sc. Tech.,**13(**2),9 (2008).
4. S. Chirarattananon and J. Taweekun, ENERG CONVERS MANAGE, , **44**(5), 19 (2003).
5. R. Saidur, Energy Policy, **37**(10), 9 (2009).
6. The Energy Conservation Center, Japan, (2010).
7. M.C. Katafygiotou and D.K. Serghides, Energy Buildings, **72**(0), 8 (2014).
8. X. Li, H. Tan, and A. Rackes, J. Clean. Prod. , **106** (11), 11 (2015).
9. W.-H. Hong et al., J. Asian. Archit. Build., **10**(2), 7 (2011).
10. L. Vásquez et al., J.Clean. Prod. (to be published)
11. A. Escobedo et al., J. Sustain. Dev. Energy, **18**(0), 6 (2014).
12. E. Azar & C.C. Menassa, Energy Policy, 2014. **67**(0), 13 (2014).
13. O.F. Kofoworola & S.H. Gheewala, Energy Buildings, **41**(10),17 (2009).
14. S.M. Library, *UI GreenMetric World Universities Ranking*. 2015 [cited 2015; Available from: http://stang.sc.mahidol.ac.th/text/ranking.htm#uigreen
15. Thumann, A. and W.J. Younger, *Handbook of Energy Audits, Seventh Edition*. 2007: Taylor & Francis
16. IPCC, *2006 IPCC Guidelines for National Greenhouse Gas Inventories* 2006, IGES, Japan The National Greenhouse Gas Inventories Programme
17. TGO, *Summary Report The Study of emission factor for an electricity system in Thailand,* (2010).
18. D. Staniaszek & E. Lees, *Determining energy savings for energy efficiency obligation schemes.* Montpelier, Vermont: ECEEE, RAP (2012).